THE BRAKE PAD PARTNERSHIP
Compilation of Technical Reviewers' and Stakeholders' Comments on
Bay Modeling Draft Report
November 14, 2007

Background

On behalf of the Brake Pad Partnership, URS has conducted bay modeling of the environmental fate and transport of copper from vehicle brake pad wear debris and other copper sources in order to better understand how copper travels through the environment and what the relative significance is of copper from brake pad wear debris on copper levels in the San Francisco Bay. The bay modeling effort is the last of three interlinked modeling components at the core of the Partnership's technical studies. An air deposition model was used to estimate the amount of copper from brake wear debris and other air releases of copper that is deposited in the watershed. The results of that model provided some of the inputs to the watershed model. A watershed model was used to estimate the relative amount of copper from brake wear debris that is discharged from the watershed in runoff to the San Francisco Bay. The information from these two models along with source term estimates provided inputs to the bay model, which will estimate short- and long-term concentrations of copper in the South San Francisco Bay.

The work plan for the bay modeling effort was reviewed and approved and is available at http://www.suscon.org/brakepad/documents.asp. Final results for the air deposition modeling, the watershed modeling, and the source release inventory effort can be found at this site as well.

The Brake Pad Partnership Steering Committee is seeking an independent expert review of bay modeling results for the environmental fate and transport of copper to ensure that the approach and results of this element of the Partnership's work are technically sound, to determine if there are feasible opportunities to strengthen the presentation of the results, and to help build in-depth understanding of and confidence in the technical studies on the part of the Steering Committee and the stakeholder communities.

Charge to Reviewers

With the aim of meeting these objectives, the Steering Committee is seeking comments that specifically address the following questions:

1. In your assessment, do the modeled results adequately estimate the relative contribution from vehicle brake pad wear debris to copper levels in the San Francisco Bay? What improvements, if any, do you recommend for the presentation of results?
2. In your assessment, do the modeled results adequately present the level of uncertainty involved in the amount of copper from vehicle brake pad wear debris that is present in the bay? Do the modeled results adequately represent the uncertainty in the relative contributions of copper in the bay from brake pad wear debris and from non-brake pad copper sources?

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COMMENTS RECEIVED

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From Jerome Maa, Virginia Institute of Marine Science (October 20, 2007)

Question 1: In your assessment, do the modeling results adequately estimate the relatively contribution from vehicle brake pad wear debris to copper levels in the San Francisco Bay? What improvements, if any, do you recommend for the presentation of results?

It appears to me that the total amount of copper generated from the brake pad wear debris can be estimated from the total number of cars and trucks registered in local governments that are associated with each watershed and the average wearing rate. Of course, some of the debris may never come to the San Francisco Bay, but in general, the majority of the debris will come to the bay sooner or later. With this information, the relatively contribution from brake pad wear debris can be further confirmed. For example, if URS found that 90% of the debris generated comes to the bay, then the relative contribution would be more convincing. This information should be relatively easy to obtain and very useful.

Question 2: In your assessment, do the modeled results adequately present the level of uncertainty involved in the amount of copper from vehicle brake pad wear debris that is present in the bay? Do the modeled results adequately represent the uncertainty in the relative contribution of copper in the bay from brake pad wear debris and from non-brake pad copper sources?

The exchange of sediment (and thus, absorbed copper) between those in the water column and those in the sediment bed has not clearly described. Unlike other processes, how these sediment transport parameters were selected has not been spell out in the draft report neither. This leads to a big uncertainty on the modeling effort regarding the amount of copper released from buried sediment during erosion events and the amount deposit on the sea floor and later buried (during calm weather conditions). This reviewer has suggested at an early review that these sediment parameters should be acquired via in-situ measurements to provide a reasonable range for uses, at least for two of the three important parameters (erosion rate, critical bed shear stress for erosion and settling velocity). It appears that these parameters are still selected arbitrary. Even the sensitivity study to demonstrate the relatively importance of each sediment parameter is not performed.

Other specific comments:
p.2-4., line 3. The flows were scaled down appropriate. What is “appropriate?”

p.2-4. It said that point sources are input with a flow and a concentration. But then a default 0.1 m/s was applied: for marina input, for publicly owned treatment work and industrial point sources, for tributaries. What is this default 0.1 m/s coming from? Why it has a unit of m/s?

P.2-10. What is the meaning of “Suspended matter can be produced in the water column by primary production.” Are we talking about biological production? or how sediment can be produced in the water column? It is hard to under this paragraph.

p.2-10. It has been shown (e.g., Maa and Kim, 2002) that the sediment erosion rate can be 10 to 50 times different if there is a storm event. For this reason, it is not clear why only the dry season values were applied? At least an average value, weighted by the duration for wet and dry period, should be used.

p. 2-11. There is no settling or density difference to cause vertical gradient for dissolved copper concentration. In general, even with density difference for salty water, the salinity would be rather uniform for shallow water area. For this reason, the argument presented in the paragraph before Sec. 2.2 is not convincing. What is the water depth for those measurement stations?

p. 4-3. It is not clear why the sensitivity runs for temperature and salinity are necessary. Is it because the ECO lab results showing a significant dependence? This appears conflicted with the statements given in “Forcing” (in P. 2-10).

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From Brent Topping, U.S. Geological Survey (November 6, 2007)

1. My general impression is that this is a useful exercise, but it is very hard to know how effectively it can estimate the BPWD contribution to Cu levels in the Bay. First of all, I'm not a modeler, so I can't comment knowledgeably on whether the models are well constructed. However, I'm concerned that the report doesn't effectively disclose what is really being modelled, relative to BPWD. In other words, it seems to me that the driving force between the estimates of "Mid" and "Mid-No-BP" is simply the Aqua Terra 2007 tributary input estimates. I think this should be emphasized more. Or, if I'm wrong, and the authors believe that the hydrodynamics of the South Bay are the determining factor, please ask them to discuss this further.

2. Again, I'm not an expert on the modelling process, but this report seems to focus only on the uncertainty of the model in terms of its sensitivity to certain inputs. I would suggest a lengthy paragraph discussing the uncertainty in determining the effect of BPWD on Cu levels in the Bay. Again, I'd also suggest that the authors acknowledge that much of the uncertainty is likely carried over from the uncertainty in the Aqua Terra 2007 report. I think Figures 24c and 24d dramatically show how much influence these tributary inputs have on the model. I don't believe that the authors adequately expressed their awareness of this in the explanation (Section 4.2, 2nd paragraph).

page 2-6, first full paragraph: The model may not have the capability to incorporate it, but the presence of benthic biota (worms, clams, etc.) can increase the transport of dissolved metals beyond what would be expected through diffusion alone. Please see:

http://toxics.usgs.gov/pubs/wri99-4018/Volume2/sectionA/2214_Kuwabara/pdf/2214_Kuwabara.pdf

and look at Figure 4 showing the difference between assumptions of diffusion-only versus directly measured flux (with live macroinvertebrates in the sediment).

page 2-7, just before the second full paragraph: I don't understand using such as indirect method for determining the copper concentrations is the ocean boundary. If you're citing the SFEI already, why not use their dissolved copper concentrations at site BC20 (well beyond the Golden Gate). The resulting difference is massive (less than 1 ug/L (RMP) vs. 44 ug/L (Table 2). Using assumptions like this are always better than nothing, but when major differences between the calculated value and the observed value appear, changes need to be made.

The model does seem to be able to overpower this input: all modelled values for BC20 are at or below 1 ug/L (see Figure 16m). Still, it should be addressed to justify the accuracy of the starting parameters.

page 2-10, 5th paragraph: This is a reasonable assumption for copper, and the argument could be strengthened by noting that another dissolved metal not studied here (Cd) exhibits considerable dependence on salinity values.

page 2-11, first paragraph in section 2.2, right after "AQUA TERRA 2007:" I would suggest a more specific reference here. Is the Powerpoint presentation I found online really the only published source of this information? If so, could that table of data be copied within this report. It seems like important information to delineate since it likely drives much of the difference between Mid and Mid-No-BP, especially the site-specific differences - assuming the air deposition component is relatively uniform over the whole Bay.

page 3-3, third paragraph in section 3.2.2: Table 6 indicates that the Lower South Bay benthic Cu concentration will drop 50% inside of 10 years before stabilizing. Why don't the report authors comment on this dramatic shift?

page 4-2, second full sentence: "fairly similar" is not a quantitative term, and does not describe what I see. Also, why casually dismiss the "wet season" differences when it is the wet season runoff which would likely bring more BPWD into the Bay.

page 4-3, after section 4.4: Why not include a plot here to prove the point that Temp/Salinity forcings are not important in determining Cu values?

Table 2, row for Pacific Ocean Boundary Conditions: See note for page 2-7 for further remarks. Unnecessary assumptions are being made to derive the dissolved value. At the least, use a range of values, as was done for the delta boundary below.

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From Kelly Moran, TDC Environmental (November 9, 2007)

This memorandum contains comments from BASMAA reviewers on the draft San Francisco Bay modeling report prepared by URS for the Brake Pad Partnership (BPP). Enclosed with this memorandum is a short letter from Dr. John Oram of the San Francisco Estuary Institute, who we asked to review the draft report. Dr. Oram specializes in water quality modeling of San Francisco Bay. His comments, which are attached, address a set of questions provided by BASMAA. We request that the BPP consider these comments in addition to our own.

Overview

The way the Bay modeling was implemented appears to provide a reasonable estimate of the contribution of copper in vehicle brake pads to copper levels in San Francisco Bay. While we have a few questions about specific elements of the modeling, overall, we believe that the modeling of San Francisco Bay completed by URS is suitable to serve the needs of the BPP.

Specific Comments and Questions

Our substantive questions and comments are listed below. These comments include technical questions and recommendations for additions or revisions to the report to increase its clarity.

- Watershed entry points. BASMAA appreciates the BPP's and URS's early response to our query about the selection of the watershed entry point for the Upper Alameda Creek Modeled Watershed. We understand that the typo in Table 3 will be corrected and that the text will be amended to identify the mis-placement of this watershed entry point and to note that the impact of this minor error is believed to be insignificant.
- Lower South Bay watershed entry points. The selections of the locations of the four watershed entry points in the lower South San Francisco Bay is not intuitive and has caused much discussion among BASMAA reviewers. It would be helpful for the report to clarify why the locations of SC1 and SC2 are appropriate and why the other two entry points (SC 3 and SC4) appear to be in the middle of the Bay, rather than on the shoreline.
- Mass balance. The mass balance for the lower South Bay (Section 3.2.3) estimates that 99.96 percent of the total copper in the system is in the sediments. What are the implications of this relative to the brake pad copper modeling results?
- Modeled benthic copper concentrations. The 10- and 20-year data for lower South Bay in Table 6 and the accompanying discussion in Section 3.2.2 do not appear to match the results in Figure 19. The table shows lower South Bay concentrations decreasing from the initial model concentration, while the figures appear to show increases.

We believe that the following changes would improve the usefulness and clarity of the report:

- Add description to enhance credibility of BPP-conducted studies. In Section One, it would be helpful to provide a short explanation of the framework of the BPP studies (i.e., the boxes in Figure 1) that identifies the studies that were specifically prepared to provide input data for this Bay modeling report. We believe that is important to explain that the BPP studies were completed with the cooperative oversight of the BPP Steering Committee and were peer reviewed by the BPP Scientific Advisory Team. The cooperative approach to preparation of these input data distinguishes the BPP-supplied

studies from other information sources that happen to have relevance to this work. The cooperative approach and the peer review lend credibility to the BPP-supplied inputs. When BPP-funded studies are mentioned for the first time in the body of the report, it would be helpful to identify them as BPP studies.

- Add description to enhance credibility of previous related Bay modeling. This modeling relies heavily on previous modeling completed by URS. The previous modeling was subject to extensive peer review. In Section One, it would be very helpful to briefly summarize the context and review process for the previous modeling, which will enhance its credibility among readers who are not familiar with that work.
- Note that wastewater discharge copper form assumption is conservative (page 2-8). We suggest substituting "conservatively assumed" for "assumed" in the last sentence in the first full paragraph on page 2-8. This would clarify that copper in wastewater discharges is usually somewhat less than 100% dissolved.
- Explain why dry season calibration parameters were used (page 2-11, first paragraph). The report would be improved if it included a more detailed explanation of the rationale for using 1997 dry season calibration parameters (rather than wet season parameters or averages). Would this selection affect instances of poorer fit noted in the next paragraph (which seem to mostly be wet season)?
- Clarify transect placement (page 3-1). Please clarify if all transects are west to east shore, or is Golden Gate transect from Marin to San Francisco?
- Data presentation. In addition to the figures presenting modeling results, a few tables with numbers are needed to assist the reader in evaluating and interpreting the relative significance of the brake pad copper to different segments of the Bay. Such numeric summaries will make the information in this report more accessible for future users. We recommend three types of new summary tables below. If the specific formats we suggest are costly, we would appreciate the team's consideration of less costly methods of presenting quantitative results that address these needs.

    1. *Relative contribution of brake pads to water column copper concentrations.* Prepare a table analogous to BPP watershed modeling report Table 3.4. For each of the 11 stations in Figure 18, the table should present:
        i. the relative range of wet weather dissolved copper contribution from brake pads
        ii. the percent that the brake pad copper increment represents of the ambient concentration range at each station

        These ranges would of course have to be somewhat qualitative and may require "best professional judgment" in selection. However, some summary like this is needed to help inform data interpretation and assist with more extensive station-by-station, and/or Bay segment-by-segment discussion of the results in Section 3. Without this level of information, it is challenging to evaluate the technical robustness of qualitative statements in the report (i.e., statements like that in the second paragraph of Section 3.2.1, which provides an the analysis of the relative importance of brake pad copper, but relies on information not currently available to the reader).

    2. *Benthic copper data summary*. Modify Table 6 to include results from all 11 stations in Figure 19 for the initial, 10-year, and 20-year benthic copper results. It

would also be helpful to include combined data for three hydrologically similar Bay subsections: (1) North and Central Bays, (2) South Bay above Dumbarton Bridge, and (3) Lower South Bay. In the case of the North and Central Bays, we recognize that for purposes of this model's original development, URS defined Central Bay as ending north of Bay Bridge (as indicated in Figure 2 and in the text at the top of page 4-2). However, if possible, it would be helpful if interpretive discussion could use the new regional standard definition of the Central Bay, which, based on extensive review of Bay data, is now understood to extend hydrologically from Richmond Bridge to San Bruno Shoal. (This newer definition is used by the San Francisco Bay Regional Monitoring Program and by the San Francisco Estuary Institute's multi-box model of the Bay). Alternatively, if this is not easy to do, we suggest simply inserting a note mentioning this evolving definition of Bay segmentation as clarification for local readers.

3. *Table summarizing cumulative probability plots*. A summary table of the Figure 20 results would be useful in improving the understanding of the significance of the brake pad copper contribution. It is suggested that the table include the dissolved copper concentrations representing the 50^{th} and 90^{th} percent probabilities for each of the two scenarios for each station.

- Explain San Pablo Bay's lack of sensitivity to local copper loads (pages 4-1 to 4-2). It appears that the sensitivity analysis did not zero out copper loads from the Central Valley. If so, the discussion should note that copper loads from the Central Valley are very large compared to local sources into the North Bay, which explains outcome of this sensitivity analysis for the North Bay.
- Additional discussion of results. We suggest that the discussion section be expanded to include more comparisons of results organized by the three more hydrologically similar areas: North/Central Bays, South Bay above Dumbarton Bridge, and lower South Bay. (Ideally this expanded discussion would be able to reference the recommended summary tables). Given that the copper contribution from brake pads appears highest in the lower South Bay, more discussion of lower South Bay results is particularly warranted. This regional information will be useful in the future to help identify and prioritize overall copper management actions bay-wide.
- Clarify the source of marina copper concentrations in Table 5. Please add "estimated" or "calculated" (or similar wording) to the header of the column listing copper concentrations. This will clarify that the concentrations were estimated by URS based on data from Process Profiles; these are not measured concentrations.
- Add "Sources of Runoff Loads" box to Figure 22. In Figure 22 (lower South Bay mass balance) add a text box showing the sources of runoff loads breakdown of brake pad and non-brake pad copper as was done for Figure 23 (overall Bay mass balance).

ATTACHMENT

The following minor editorial items were identified during our review:

- P. 2-9, line 1. Correct spelling of "desporption."
- Page 3-2, second paragraph, second sentence. Replace "suggesting and increasing influence of BPWD…." with "suggesting an increasing influence of BPWD…."

- Page 4-2, first paragraph. This paragraph contains a sentence fragment.
- Figure 19 (j2). Caption contains a typo—it should match (j1).
- Figure 20. It would be easier to follow this series of figures if the same X-axis scale were used throughout.

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From John J Oram, San Francisco Estuary Institute (November 9, 2007)

1. Are the general objectives of the workplan are still met, or if not what are biggest concerns for BPP?

It seems that the objectives of the modeling workplan are met. The main objectives were to develop a Bay model (or models) to estimate the short- and long-term effects of brake pad wear debris (BPWD) on Bay copper concentrations. I certainly feel these objectives were met. The original workplan did mention the development of two Bay models; one for short-term predictions and another (potentially the SFEI/USGS multibox model) for long-term predictions. The work performed strayed from this plan, though it seems there was steering committee approval. Being the developer of the multibox model I would have liked to see its use, but it is my professional opinion that the model used here is appropriate for assessing both short- and long-term effects.

2. Are there general concerns with model construction or inputs as reported in section 2.1? I don't expect you to be familiar with all of them but you'll be way ahead of me. I did note one potential issue in watershed inputs (see below) but don't know how much discrepancy it might produce in terms of overall model prediction.

I do have some concerns about the use of a two-dimensional hydrodynamics model for San Francisco Bay. Such models are appropriate where water column stratification is negligible. It has been shown, however, that San Francisco Bay is not uniform in the vertical (i.e., it is stratified) and that the Bay exhibits highly complex flow patterns, especially near the Delta and Golden Gate. Furthermore, considerable freshwater inputs to the Bay increase stratification and drive gravitational circulation patterns that are not well parameterized by a two-dimensional model. A three-dimensional model is more appropriate to resolve these complex flows. The grid nesting approach is reasonable, and a good trade off in exchange for ability to run long-term model runs.

I have considered you concerns regarding the spatial distribution of inputs (both freshwater and copper) from local watersheds. While it is certainly best to get their distribution as close as possible to reality, I don’t think there placement in the existing model poses much of a problem. The uncertainty in estimating the inputs from these watersheds (as assessed by the watershed model) are likely larger than the potential effects of there geographical misplacement, given the misplacement is small. In addition, the depth-integrated model, and comparison to observations at particular depths, is likely a larger contributor to the discrepancies you note in current velocities. On the other hand, the differences you note do not raise any real alarms with me.

Predictions are generally comparable to observations and time trending (e.g., seasonal patterns) is captured.

3. Do some limitations or caveats deserve better documentation or discussion in the report? This would be most helpful as specific suggestions where to insert language to (a) clarify background on issues with Bay modeling in general, (b) highlight parameters or modeling choices to which model outcomes are probably most sensitive, or (c) identify other scenarios or sources of input that would be priorities for follow-up in the event that funds were found to pursue questions that were not answered sufficiently in this report.

Overall the report captures most details. A few more details would be helpful:

- How were the various bathymetry data sources interpolated to create the model grids? Some sort of objective mapping?
- Would like to see the ranges of Manning's n.
- Why was 0.1 m/s used as velocity for all inputs from tributaries, POTWs, and marinas? Seems that these inputs should have unique velocities. Effects may be small but would affect the momentum transfer in the near-field.
- Typo- page 2-8 second to last paragraph : As a result, …'wet' should be 'dry'
- I would like to see some discussion and validation of the sediment model. It seems that there is no real sediment transport model, but rather an accounting of the processes in terms of how they affect copper fate. I may be mistaken. Some discussion is certainly warranted. What are predicted suspended sediment concentrations? What are predicted sedimentation rates?
- Using particle settling, resuspension rates, and critical velocity as calibration parameters concerns me. Too many degrees of freedom here. As one technical reviewer noted (Jerome Maa), this opens the possibility that the right results are reached for the wrong reasons.
- Ignoring effects of temperature, salinity, pH, etc. on copper partitioning seems reasonable. Partitioning coefficients in this case seem to capture the seasonal variability that these parameters would introduce.
- Results of sensitivity analysis to external loads are conceptually reasonable. Would have been more powerful to do these sensitivity tests over more than one water year.
- Discussion of sensitivity to initial benthic copper concentrations seems to overstate the BPWD contributions during wet/dry conditions (bottom of page 4-2). Related, I am not surprised the sensitivity to BPWD, and loads in general, is greater when the model is initialized with equilibrium benthic copper concentrations. Under such conditions, the sediment represents less of a 'sponge' and its buffering capacity is reduced (i.e., sediment response times to loads are shorter).

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From Bob Peters, Akebono Brake Corporation (November 12, 2007)

Page 3-2. second paragraph - spelling error - "suggesting an~~d~~ increasing" should read "suggesting **an** increasing influence of BPWD."

Page 3-2 second paragraph - sometimes Brake Pad Wear Debris is abbreviated with BPWD and in other areas it is abbreviated with BPDW.

There are numerous other typo's (ie., page 2-9 1st paragraph "desporption", page 2-10 "verification is describe in the following….")

I would prefer page numbers for the figures and tables listed in the table of contents.

Page 3-2 second paragraph "could be an effect of the hydrologic conditions ….." Could this be spelled out – what hydrologic conditions – I assume that means dry vs. wet years?

Page 3-2 third paragraph. The last sentence states "From a temporal perspective, copper contribution from BPDW is highest during the wet season." Are you saying it's highest over the wet season because the first big storm event has a high build up of copper or that copper concentration is less per storm event but is still greater over the entire (wet) season. Could this be clarified?

Page 3-3 last paragraph of section 3.2.2. Given the uncertainties in the model inputs and source terms, is 1.5% significant?

Page 3-3 section 3.2.3. 1500kg of copper is the stated amount of total runoff and air deposition for the lower south bay area. Is that correct, it seems rather low? Is it specific to 1997? If so – how was it measured? Does it match loadings predicted by the watershed model? How about footnoting the source of that loading information?

Page 3-3 section 3.2.3 The mass balance indicates a difference in predicted copper inventories relative to the measured amounts in the lower south bay for part of 1997. The model predicts a net gain and the measurements indicate a net loss – this needs more explanation. There is a hypothesis presented but if the difference really is correct it seems to me this has a cumulative effect that can put the inventory trend way off. This either needs more investigation or the explanation needs to go further in defining why the simulation and the measured data don't correspond.

Table 6. I would like to see uncertainty addressed in table 6. Also, I assume that the column labeled "10 years" is at the 10 year mark and not the average of the first 10 years – same for the next column. Could this be clarified?
The degree of resolution implied by 52.4 is probably way greater than uncertainties would dictate.

Figures 22 & 23 I assume the loads quoted are from Kirsten's loading inventory and/or the watershed model based on the "methodology" section but the graphs would stand on their own better if the figures had this info noted explicitly.

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From Kirsten Rosselot, Process Profiles (November 14, 2007)

General comments:

URS has done a good job of painting a picture from data that are difficult to convey. The variations in copper concentrations for water years, from location to location, from one season to the next, and during the course of the modeling are difficult to grasp.

Specific comments:

Sub-watersheds: Partnership convention for the technical studies has been to refer to the 22 study watersheds as sub-watersheds of the San Francisco Bay watershed. These 22 study watersheds are referred to as superwatersheds in the draft bay modeling report, which in a way makes sense because they are groups of watersheds that URS conducted bay modeling for previously. However, the bay modeling report needs to be consistent with the rest of the Partnership's technical studies documents and refer to the 22 modeled watersheds as sub-watersheds. Perhaps the watersheds modeling in URS' previous work could be referred to as catchments, just to distinguish them from the Partnership's subwatersheds.

Table 3 is referred to in the text before Table 2.

As I understand it, the scaling factors in Table 3 are applied to runoff from the various subwatersheds in order to assign runoff from the Partnership's subwatersheds to the previous bay modeling subwatersheds, so the scaling factors for each sub-watershed should add up to 1. The scaling factors in Table 3 for the Peninsula subwatershed add up to 1.32. I understand that the Colma subwatershed runoff is included in the Peninsula subwatershed at SM4, but the scaling factor for that location for the Peninsula subwatershed is 0.05. I think it would help make this clear if the location for Colma was listed in the table with Colma as the subwatershed. The other four Partnership subwatersheds with upstream subwatersheds assigned to them have scaling factors that add up to 1 or close to 1. The scaling factors for Solano West add up to 3.1, and this subwatershed does not include runoff from upstream subwatersheds. The scaling factors for Contra Costa Central add up to 1.06.

It might be a good idea to note that the North Napa and North Sonoma sub-watersheds are not included in this table because their runoff is included in the Napa and Sonoma sub-watersheds, because the text mentions 22 sub-watersheds and Table 3 only mentions 20 because the bay only sees 20.

inputs direct to bay waters

p. 2-4, maybe this should clarify that it includes copper from pressure-treated wood used in marine construction and copper released from antifouling coatings used on boats.

I don’t think you mentioned copper in algaecides released to shoreline surface waters and while this source may not be important, that loop needs to be closed.

p 2-11, at the bottom, there's a sentence that reads "The results of the watershed model showed that the total copper loads to the Bay did not vary significantly between each level of contributions…" Part of the reason for this is that some of the parameters were adjusted differently for each of the three pairs of watershed modeling runs. There's quite a bit of variation in the location of the copper in runoff even though the total copper in runoff is close to the same for all three runs. I think it would be better to say that conducting bay modeling for the mid-brakes case with brakes and for the mid-brakes case without brakes will show whether the results of the bay modeling are sensitive enough to variations in runoff for the three pairs of watershed modeling runs to make running high-brakes and low-brakes cases worthwhile.

Figure 17's caption is messed up.

The locations described by Figure 18 need to be on a map where they can be identified. I found Bay Bridge as station 4317 in one place and elsewhere identified as Bay Bridge/Yerba Buena Island (different locations). I couldn’t find in the writeup how to correlate the locations for the Figure 18 descriptions to a physical place in the bay. I think you should point out in the text that the scales of parts 2 of those graphs is not the same as the scale for the parts 1 of those graphs, or change them to % difference rather than absolute difference. The absolute different increases as the concentration in the bay goes up but the fraction of concentration due to brake pads seems to be about 10-20% everywhere, and if that's so, it’s interesting. Figure 19 is the same -- is the fraction of copper in benthic sediments due to brake pads 3-4% at every location?

The description of Figure 23 needs to explain why the copper in runoff in 1999 was only 29,000 kg when the average runoff from the watershed modeling is around 55,000 kg/y. A table that showed total copper in runoff for all the modeled years would help make this more understandable.

Did the results of the sensitivity to copper loads in section 4.2 indicate that modeling of the high brakes and low brakes cases with and without brakes would not provide further illumination into the impact of copper from brake pads on copper concentrations in the bay? Is there any way you could bracket the differences you would expect to see in the bay from the three pairs of scenarios?